

# **Did the Great Recession affect mortality rates in the metropolitan United States? Effects on mortality by age, gender and cause of death**

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## Abstract

**Objectives:** Mortality rates generally decline during economic recessions in high-income countries, however gaps remain in our understanding of the underlying mechanisms. This study estimates the impacts of increases in unemployment rates on both all-cause and cause-specific mortality across U.S. metropolitan regions during the Great Recession.

**Methods:** We estimate the effects of economic conditions during the recent and severe recessionary period on mortality, including differences by age and gender subgroups, using fixed effects regression models. We identify a plausibly causal effect by isolating the impacts of within-metropolitan area changes in unemployment rates and controlling for common temporal trends. We aggregated vital statistics, population, and unemployment data at the area-month-year-age-gender-race level, yielding 527,040 observations across 366 metropolitan areas, 2005-2010.

**Results:** We estimate that a one percentage point increase in the metropolitan area unemployment rate was associated with a decrease in all-cause mortality of 3.95 deaths per 100,000 person years (95%CI -6.80 to -1.10), or 0.5%. Estimated reductions in cardiovascular disease mortality contributed 60% of the overall effect and were more pronounced among women. Motor vehicle accident mortality declined with unemployment increases, especially for men and those under age 65, as did legal intervention and homicide mortality, particularly for men and adults ages 25-64. We find suggestive evidence that increases in metropolitan area unemployment increased accidental drug poisoning deaths for both men and women ages 25-64.

**Conclusions:** Our finding that all-cause mortality increased during the Great Recession is consistent with previous studies. Some categories of cause-specific mortality, notably cardiovascular disease, also follow this pattern, and are more pronounced for certain gender and age groups. Our study also suggests that the recent recession contributed to the growth in deaths from overdoses of prescription drugs in working-age adults in metropolitan areas. Additional research investigating the mechanisms underlying the health consequences of macroeconomic conditions is warranted.

**Keywords:** United States, economic recession, mortality, cause of death, metropolitan area, age-specific mortality, gender-specific mortality, Great Recession

## Introduction

Since the influential work of Ruhm,(C.J. Ruhm, 2000) empirical research conducted on a variety of high income countries has found that mortality largely varies procyclically with the business cycle.(Ariizumi & Schirle, 2012; Buchmueller et al., 2007; Gerdtham & Ruhm, 2006; Miller et al., 2009; Neumayer, 2004; Stevens et al., 2015; José A Tapia Granados, 2005a, b, 2012; José A Tapia Granados & Ionides, 2011; José A Tapia Granados & Roux, 2009) That is, over and above long-term trends, mortality rates decline during recessions.

Investigations of specific causes of death have been used to gain insights into the mechanisms underlying this relationship. Deaths from cardiovascular disease, felt to be responsive to short-term changes in modifiable health behaviors and environmental stressors,(Grundy et al., 1999) have been widely examined and found to vary procyclically.(Buchmueller et al., 2007; Gerdtham & Ruhm, 2006; Neumayer, 2004; C.J. Ruhm, 2000, 2007; Stevens et al., 2015; José A Tapia Granados, 2005a; José A Tapia Granados & Ionides, 2011; José A Tapia Granados & Roux, 2009) Specifically, temporary increases in deaths from coronary heart disease may explain as much as two thirds of the increase in heart disease deaths during periods of economic growth, while other subcategories of heart disease deaths decrease during those same periods.(C.J. Ruhm, 2007) Procyclical patterns have also been documented for external causes of death. For instance, there is strong and consistent evidence that economic declines are associated with reductions in traffic accident mortality(Buchmueller et al., 2007; Gerdtham & Ruhm, 2006; Neumayer, 2004; C.J. Ruhm, 2000; Stevens et al., 2015; José A Tapia Granados, 2005a, b; José A Tapia Granados & Ionides, 2011; José A Tapia Granados & Roux, 2009) and some evidence of reductions in mortality from other accidents.(Buchmueller et al., 2007; Gerdtham & Ruhm, 2006; C.J. Ruhm, 2000; Stevens et al., 2015) However other causes of death do not exhibit a consistently procyclical pattern, including cancer (generally acyclical(Buchmueller et al., 2007; Neumayer, 2004; C.J. Ruhm, 2000; José A Tapia Granados, 2005b; José A Tapia Granados & Ionides, 2011)), homicide (mixed(Gerdtham & Ruhm, 2006; C.J. Ruhm, 2000; D. Stuckler et al., 2009) (Neumayer, 2004; José A Tapia Granados, 2005b; José A Tapia Granados & Ionides, 2011)), and suicide (mixed(Buchmueller et al., 2007; Gerdtham & Ruhm, 2006; Nandi et al., 2012;

Neumayer, 2004; C.J. Ruhm, 2000; Stevens et al., 2015; D. Stuckler et al., 2009; José A Tapia Granados, 2005b; José A Tapia Granados & Ionides, 2011)).

Accumulating evidence demonstrates that the impacts of macroeconomic conditions on health are unlikely to operate primarily via the employment experience of individuals(J. A. Tapia Granados et al., 2014). Per capita work hours have been shown to be negatively related to mortality in some countries.(Johansson, 2004) Analyses of macroeconomic effects on mortality in elderly populations, a group with low labor force connection, have sometimes demonstrated stronger responses than for some categories of working age individuals.(Buchmueller et al., 2007; Neumayer, 2004; C.J. Ruhm, 2000) Recent studies have found the strongest sensitivities to macroeconomic conditions among young adults (largely from traffic fatalities), with smaller impacts among the middle aged.(Ariizumi & Schirle, 2012; Miller et al., 2009; Stevens et al., 2015) The procyclical mortality effects among the elderly are more modest, though this group experiences the highest mortality rates and ultimately the vast majority of ‘excess’ deaths attributable to macroeconomic activity.(Miller et al., 2009; Stevens et al., 2015)

The 2007-2009 Great Recession in the U.S.(Business Cycle Dating Committee, Sept 20 2010) was characterized by a larger increase in the unemployment rate than in previous post-WWII recessions and an atypically slow recovery.(U.S. Bureau of Labor Statistics, Dec 2010) Research on the health effects of this recession has established weak or no impacts on smoking and alcohol consumption,(Nandi et al., 2013; Tekin et al., 2013) increases in exercise(Colman & Dave, 2013; Tekin et al., 2013) and adiposity,(Latif, 2013) and decreases in vehicle miles traveled by safer (e.g., older) drivers.(Maheshri & Winston, 2016) County-level analysis has shown that adverse economic conditions, as measured by poverty rates and lower median incomes, lead to higher mortality.(Gordon & Sommers, 2016) Increases in suicide attributed to the recession have been observed in several European countries,(Barr et al., 2012; Corcoran et al., 2015; Kondilis et al., 2013; Lopez Bernal et al., 2013; David Stuckler et al., 2011) as have declines in traffic deaths(Regidor et al., 2013; David Stuckler et al., 2011) and premature mortality,(Regidor et al., 2013) although few of these studies had designs which permitted causal inference.(Parmar et al., 2016) Recent analyses have found the relationship between

macroeconomic conditions and overall mortality to remain procyclical overall(Lindo, 2015; C. J. Ruhm, 2015), but also evidence of a shift towards acyclicity in recent years due to countercyclical upsurges in cancer and accidental poisoning deaths.(C. J. Ruhm, 2015)

This study contributes to the existing literature on economic conditions and health by examining the impacts of economic conditions during the recent and relatively severe Great Recession.(Business Cycle Dating Committee, Sept 20 2010) Specifically, we estimate the effects of changes in unemployment within metropolitan statistical areas (MSAs) on both all-cause and cause-specific mortality from 2005-2010. MSAs are population centers and their adjacent communities with a high degree of social and economic integration, and therefore reflect local labor markets. Approximately 84% of the US population lives in MSAs(U.S. Census Bureau, 2012). Given recent countercyclical findings for accidental poisoning(C. J. Ruhm, 2015) and epidemiological data on prescription drug overdose deaths,(2012) we investigated accidental drug poisoning specifically. We further examine age- and gender-specific effects by cause of death in order to better understand the mechanisms at work. Some of the most widely-cited studies that examine the impacts of the recent recession on mortality do not convincingly identify causal relationships.(David Stuckler et al., 2011) We therefore contribute further to this literature by using more rigorous methods(C.J. Ruhm, 2000) to plausibly identify the effects of the Great Recession on mortality.

## Methods

### Data and Sample

We calculated mortality rates based on data from the Centers for Disease Control and Prevention's National Vital Statistics System.(U.S. Department of Health and Human Services et al., 1980-2010) Underlying causes of death were designated through International Classification of Diseases (ICD) codes version 10 (ICD-10). We used auxiliary information available on the state and county of residence of the decedent, and their age, sex, race, and time of death, to generate month-MSA-subgroup-specific mortality rates. Within each MSA we stratified monthly mortality totals by age (0 to 15, 15 to 24, 25 to 44, 45 to 64, and  $\geq 65$  years old), sex, and race

(white, non-white), using county of residence to map to MSAs. We used 366 MSAs, geographic areas made up of counties with at least one urbanized core (population  $\geq 50,000$ ) and integrated adjacent areas (Office of Management and Budget, 2000) corresponding to the November 2008 update of area definitions. (Office of Management and Budget, 2008) Annual midyear population denominators were obtained from the Surveillance Epidemiology and End Results (SEER) U.S. population database (Surveillance Epidemiology and End Results, 2005-2010) between 2004-2011 for counties and demographic groups, aggregated to MSAs, and used to estimate monthly counts in population strata by linear interpolation. The final data set consisted of 527,040 observations at the MSA-month-year-age-gender-race level, from 366 MSAs over the period 2005-2010.

#### Exposure and Outcome Measures

Our primary exposure variable, the seasonally-adjusted MSA-level unemployment rate, was collected from the Bureau of Labor Statistics' (BLS) Local Area Unemployment Statistics database. (U.S. Bureau of Labor Statistics, 2005-2010) Given the unavailability of seasonally adjusted estimates for New England MSAs, these rates were computed from county level data and were not seasonally adjusted.

Our dependent variable was the number of deaths in each MSA-month-year-age-gender-race subgroup, overall and by cause of death. In addition to all-cause mortality, we included deaths due to malignant neoplasms, major cardiovascular disease, pneumonia and influenza, chronic liver disease, motor vehicle accidents, accidental drug poisoning, other accidents and adverse events (including transport accidents not otherwise classified, non-drug poisonings, deaths from errors in medical or surgical care, and other accidents), suicide, legal intervention and homicide. The last category, 'other cause' mortality, included all causes of mortality not attributable to those in the preceding list (see eTable 1 [INSERT LINK TO ONLINE FILE eTable 1] for relevant ICD-10 codes).

#### Statistical Analyses

We used Poisson regression to estimate the effects of the MSA-level unemployment rate on mortality counts using the general form:

$$\log(Y_{pjt}) = \beta E_{jt} + \gamma X_{jtp} + \alpha_j + \lambda_t + \Omega_{pjt} + \epsilon_{pjt},$$

where  $Y_{pjt}$  is the number of deaths in socio-demographic subgroup  $p$ , MSA  $j$ , and quarter  $t$ , and  $E_{jt}$  is the unemployment rate by MSA and quarter. We controlled for time-invariant MSA characteristics using MSA fixed effects ( $\alpha_j$ ) and common time trends using quarter fixed effects ( $\lambda_t$ ). Additionally, we controlled for a vector of MSA-quarter-subgroup indicator variables for age group, sex, and race ( $X_{jtp}$ ). We used the natural log of the MSA-quarter-age-sex-race-specific population as the offset in the regression ( $\Omega_{pjt}$ ) in order to calculate mortality rates per 100,000 population. We estimated the marginal effect of a one percentage point increase in the quarterly MSA-level unemployment rate on the mortality rate and present our findings as absolute changes in the annual mortality rate per 100,000 population in order compare the contribution of effects across outcomes and demographic groups.

We first estimated the crude association between the unemployment rate and mortality without controls (model 1). In model 2 we controlled for age, sex, and race. In model 3, we account for time-invariant confounders which vary by MSA and shared temporal trends in our outcomes by including MSA and quarter fixed effects, respectively. Under this specification, the causal effects of economic conditions were identified using within-MSA changes in unemployment as opposed to between-MSA comparisons. All analyses use robust standard errors clustered at the MSA level.

In order to investigate the underlying mechanisms of the effect of economic conditions on mortality, we examine heterogeneity by demographic characteristics using model 3 separately by sex and age, categorized as pre-working (ages 0 to 24), working (ages 25 to 64), and retired (ages  $\geq 65$ ) age groups.

#### Sensitivity Analysis

When the assumption of equal mean and variance is not met, the resulting overdispersion means that Poisson models may underestimate standard errors. As this was the case for some outcomes, we tested the sensitivity of our results by using negative binomial regression, which incorporates an additional parameter to represent unobserved heterogeneity among observations.(Hilbe, 2007; Long & Freese, 2006)

#### Results

The all-cause annual mortality rate in US MSAs was 765 deaths per 100,000, with the most prevalent forms of deaths being from ‘other-cause’ mortality (254 per 100,000), major cardiovascular disease (252 per 100,000) and malignant neoplasms (178 per 100,000) (Table 1). Several mortality rates, including motor vehicle accidents, accidental drug poisoning, suicide, and legal intervention and homicide, were two to four times higher in men compared to women. For most causes of death, the vast majority of deaths occurred among those aged 65 and older, with the exceptions of legal intervention and homicide, suicide, motor vehicle accidents, and accidental drug poisoning. The overall population across MSAs was 51% female, 79% white, 34% under age 25, 53% age 25 to 64, and 12% age 65+. The weighted mean unemployment rate during 2005-2010 was 6.5%, which increased sharply from 4.6% in 2007 to 9.7% in 2010. In 2010, the interquartile range in the unemployment rate was 8.3% to 11.0%, with highly-impacted MSAs having unemployment rates as high as 30.4%.

The associations between increases in the MSA-level unemployment rate and all mortality outcomes are displayed in Table 2 with the estimated causal effect from model 3 being our preferred estimate. All estimates are displayed with 95% confidence intervals (CI). While the adjusted association from model 2 indicates increased unemployment led to a sizeable decline of 8.01 deaths per 100,000 population annually (95%CI -12.21, -3.80), this correlation is markedly reduced by limiting identifying variation to within-MSA changes and controlling for shared temporal trends. A one percentage point increase in the MSA-level unemployment rate decreased all-cause mortality by 3.95 (95%CI -6.80, -1.10) deaths per 100,000 population annually (model 3). This is equivalent to a 0.5% decrease in mortality relative to the average all-cause mortality rate. Increases in the unemployment rate also decreased several cause-specific mortality rates: major cardiovascular disease by 2.38 deaths per 100,000 (95%CI -3.39, -1.38), 0.9%; motor vehicle accident deaths by 0.45 deaths per 100,000 (95%CI -0.61, -0.30), 3.8%; and legal intervention and homicide by 0.20 deaths per 100,000 (95%CI -0.36, -0.03), 3.2%. Our estimates provide suggestive evidence of a small increase in mortality from accidental drug poisoning of 0.10 deaths per 100,000 (95%CI -0.01, 0.21); 1.1%. We found little evidence that MSA-level unemployment affects mortality due to cancer, pneumonia and influenza, chronic liver disease, other accidents, suicide, or all other causes.

The effects of MSA-level unemployment rate on all-cause mortality vary somewhat by gender (Table 3). Interpreted as a percent-change from the gender-specific average mortality rates, a



one percentage point increase in unemployment decreased mortality among men by 0.6% and among women by 0.4%. The decline in motor vehicle accident mortality was greater among men than among women: 4.0%, compared to 3.3%. Deaths from legal intervention and homicide declined by a rate of 0.35 per 100,000 (95%CI -0.64, -0.07; 3.4%) in men with essentially no change in women (-0.04 (95%CI -0.11 to 0.04)). The absolute decline in cardiovascular disease mortality was greater among women than men, though the percentage changes were similar: 2.57 deaths per 100,000 (95%CI -3.73, -1.41), or 1.0%, compared to 2.24 deaths per 100,000 (95%CI -3.23, -1.25), or 0.9%. Our estimates also provide suggestive evidence of increases in mortality from accidental drug poisoning in both groups: among men, mortality increased by 0.13 deaths per 100,000 (95%CI -0.03, 0.29), or 1.1%; among women, mortality increased by 0.06 deaths per 100,000 (95%CI -0.02, 0.14), or 1.0%.

As expected, the absolute decreases in all-cause mortality are largest at older ages, reflecting higher mortality rates (Table 4). Interpreted as a percent-change from the age-specific average mortality rates, a one percentage point increase in the MSA-level unemployment rate reduced all-cause mortality by 1.5% among those under age 25, 0.6% among those ages 25-64, and 0.2% among those ages 65 and over. Among children and young adults, increases in the MSA-level unemployment rate reduced mortality due to motor vehicle accidents and other accidents. Adults ages 25-64 also experienced reductions in mortality due to motor vehicle accidents, but also legal intervention and homicide, and ‘other’ causes of death. The suggestive evidence of increases in mortality due to accidental drug poisoning (0.20 deaths per 100,000 (95%CI -0.03, 0.43); 1.4%) and suicide (0.08 deaths per 100,000 (95%CI -0.01, 0.17); 0.5%) are most evident in adults ages 25-64. While increases in the unemployment rate reduced deaths from cardiovascular disease (-9.59 deaths per 100,000 (95%CI -13.96, -5.22); 0.6%), we find no evidence that deaths due to external causes were significantly affected among this group.

Results of our sensitivity analyses are presented in eTable 2 [INSERT LINK TO ONLINE FILE eTable 2]. The choice of regression specification between negative binomial and Poisson generally had no meaningful impact on estimated mortality rate differences.

## Discussion

We estimated the effect of the change in unemployment rates 2005-2010 on all-cause and cause-specific mortality among the total U.S. metropolitan population. To better understand the underlying mechanisms, we also examined these relationships separately by sex and age.

Controlling for demographic confounders, time trends, and fixed differences across MSAs reduces the range of alternative explanations and strengthens a causal interpretation of our estimates.

Our results are consistent with findings from previous studies documenting that all-cause mortality varies procyclically with macroeconomic conditions. We find that certain categories of cause-specific mortality also follow this pattern, and are more pronounced for certain gender and age groups. The reductions in cardiovascular disease mortality driven by increases in MSA-level unemployment account for 60% of the all-cause effect and were slightly more important among women than men. Legal intervention and homicide mortality also declined, particularly for men and adults ages 25-64. Consistent with previous literature, we document important reductions in motor vehicle accident mortality linked to increases in area-level unemployment, effects that are most notable among men and those under age 65. We find suggestive evidence that mortality due to accidental drug poisoning increases during periods of higher unemployment, though the estimated effects are small and have borderline statistical significance. Lastly, we find that certain prevalent causes of death, including cancer, pneumonia and influenza, and suicide, are generally not sensitive to area-level economic conditions over this period.

Several recent U.S. studies have reported an attenuation of the procyclical relationship between unemployment and mortality in recent years, with some evidence pointing to the rise in accidental drug poisoning deaths during periods of economic decline.(Miller et al., 2009; C. J. Ruhm, 2015; Stevens et al., 2015) Our estimates provide suggestive evidence that mortality due to accidental drug poisoning increased more in metropolitan areas with larger growth in unemployment during the Great Recession, particularly among adults ages 25-64. While the increase in drug overdose deaths continued to increase before, during, and after our study period,(Rudd et al., 2016) our findings suggest that within-MSA increases in unemployment may have contributed to this trend.

There are several limitations to our analyses. First, the study period comprises only six years and short periods have been linked to volatility and imprecision in similar estimates.(Ionides et al., 2013; C. J. Ruhm, 2015) However, in most cases our results are consistent with previous research conducted over longer time periods. Second, recent studies have demonstrated differences in the relationship between economic conditions and mortality by decomposing their samples narrowly by age. Our broader age groups may average over such fine-grained

variations. Third, our focus on metropolitan regions enabled us to avoid the weaknesses associated with state-level analyses(Lindo, 2015) and to link this study with previous work that found that changes in the MSA-level unemployment in the same period were not consistently associated with changes in health behaviors.(Nandi et al., 2013) However, the relationship between area-level economic conditions and mortality may differ between MSAs and rural areas. This may be particularly important for deaths due to motor vehicle accidents (higher speeds and vehicle-miles traveled)(Zwerling et al., 2005) and accidental drug poisoning, as death and injury from opioid misuse are concentrated in states with large rural populations.(Keyes et al., 2014) Fourth, the relationship between mortality rates and the MSA-level unemployment rate is different from that between individual-level mortality and employment status. We did not address labor force participation as several other studies have done,(C. J. Ruhm, 2015; Stevens et al., 2015; José A Tapia Granados, 2005b) though with little difference in their conclusions. Lastly, we do not directly control for cross-MSA migration. Differential migration rates that are correlated with changes in unemployment rate would pose a challenge a causal interpretation of our results. Such concerns are lessened, however, since internal US mobility is decreasing over time and is pro-cyclical(Molloy et al., 2011). Evidence of an increase in mobility during the Great Recession is only seen within-MSAs. Cross-region migration is falling due to a decline in the geographic specificity of returns to occupations and an increase in workers' ability to learn about other locations before moving(Kaplan & Schulhofer-Wohl, 2017).

In this analysis, we show important differences in the impacts of economic conditions on mortality across age, sex, and causes of death. Additional research investigating the mechanisms underlying the health consequences of macroeconomic conditions is warranted. Further attention to variation in this relationship across causes of death, population subgroups, and urban vs. rural contexts could inform evidence-based policies. Evaluations of the ability of social and health care policies to mitigate adverse effects are also needed.

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**Table 1.** Rates and proportions of outcomes, exposure, and other covariates, 2005-2010, n=527,040 from 366 MSAs

Outcome	Weighted mean deaths per 100,000 population (Robust SEs)					
	Full Sample	Males	Females	Ages 0 - 24	Ages 25 - 64	Ages 65 +
<b>Cardiovascular disease</b>	251.7 (6.1)	247.3 (5.6)	255.9 (6.8)	2.3 (0.1)	86.3 (2.1)	1691.4 (25.0)
<b>Malignant neoplasms</b>	177.9 (3.6)	186.9 (4.1)	169.1 (3.3)	2.9 (0.0)	102.2 (1.9)	1010.9 (10.2)
<b>Pneumonia or influenza</b>	17.0 (0.6)	16.0 (0.6)	18.0 (0.6)	0.6 (0.0)	4.1 (0.1)	120.8 (4.7)
<b>Other accidents &amp; adverse events</b>	16.7 (0.7)	19.7 (0.7)	13.8 (0.6)	4.5 (0.2)	9.8 (0.3)	81.6 (3.6)
<b>Motor vehicle accident</b>	11.7 (0.5)	16.8 (0.8)	6.7 (0.3)	9.2 (0.4)	12.4 (0.6)	15.7 (0.5)
<b>Suicide</b>	11.1 (0.5)	17.7 (0.7)	4.7 (0.2)	4.1 (0.2)	15.0 (0.7)	14.0 (0.6)
<b>Chronic liver disease</b>	9.4 (0.3)	12.5 (0.4)	6.4 (0.2)	0.0 (0.0)	11.7 (0.4)	26.2 (0.7)
<b>Drug poisoning, accidental</b>	9.0 (0.4)	12.1 (0.5)	6.0 (0.3)	2.7 (0.2)	14.6 (0.6)	2.4 (0.1)
<b>Legal intervention &amp; homicide</b>	6.3 (0.3)	10.3 (0.5)	2.4 (0.1)	6.6 (0.3)	7.0 (0.3)	2.2 (0.1)
<b>Other-cause mortality</b>	254.2 (7.8)	232.7 (6.6)	274.9 (8.9)	32.6 (0.7)	92.6 (2.4)	1597.7 (47.1)
<b>All-cause mortality</b>	764.9 (16.0)	772.0 (16.2)	758.1 (16.0)	65.6 (1.5)	355.6 (7.9)	4562.8 (49.4)

Note: SE = standard error. The most common causes of “other-cause mortality” are chronic obstructive pulmonary disease, dementia, Alzheimer disease, diabetes mellitus, and sepsis, which comprise 40% of cases for this outcome in the full sample

**Table 2.** Effect of one percentage point increase in the MSA-level quarterly unemployment rate on the annual mortality rate difference per 100,000 person years, 2005-2010, n=527,040 from 366 MSAs.

	Model 1	Model 2	Model 3
<b>Cardiovascular disease</b>	-1.21 (-3.27, 0.84)	-4.73 (-7.03, -2.43)	-2.38 (-3.39, -1.38)
<b>Malignant neoplasms</b>	0.16 (-0.89, 1.22)	-1.48 (-2.25, -0.71)	-0.07 (-0.64, 0.50)
<b>Pneumonia or influenza</b>	-0.30 (-0.45, -0.15)	-0.65 (-0.83, -0.46)	-0.14 (-0.45, 0.16)
<b>Other accidents &amp; adverse events</b>	-0.04 (-0.19, 0.10)	-0.16 (-0.31, -0.02)	-0.12 (-0.47, 0.24)
<b>Motor vehicle accident</b>	-0.36 (-0.50, -0.23)	-0.37 (-0.50, -0.23)	-0.45 (-0.61, -0.30)
<b>Suicide</b>	0.10 (0.02, 0.18)	0.08 (0.02, 0.13)	0.04 (-0.01, 0.10)
<b>Chronic liver disease</b>	0.25 (0.20, 0.31)	0.21 (0.16, 0.26)	-0.01 (-0.08, 0.06)
<b>Drug poisoning, accidental</b>	0.23 (0.11, 0.35)	0.18 (0.09, 0.27)	0.10 (-0.01, 0.21)
<b>Legal intervention &amp; homicide</b>	-0.04 (-0.15, 0.07)	-0.04 (-0.20, 0.12)	-0.20 (-0.36, -0.03)
<b>Other-cause mortality</b>	0.63 (-1.16, 2.42)	-1.55 (-3.26, 0.15)	0.37 (-1.79, 1.04)
<b>All-cause mortality</b>	-0.51 (-5.40, 4.37)	-8.01 (-12.21, -3.80)	-3.95 (-6.80, -1.10)

Results indicate the absolute change in the mortality rate per 100,000 person years from a one percentage point increase in the MSA-level unemployment rate with 95% confidence interval. Estimates from Poisson regression models offset by log-transformed MSA-demographic specific population estimates.

Model 1 includes no covariates

Model 2 includes covariates for sex, age, and race

Model 3 includes covariates for sex, age, race, and indicator variables (fixed effects) for each MSA and quarter.



**Table 3.** Effect of one percentage point increase in the MSA-level quarterly unemployment rate on the annual mortality rate difference per 100,000 person years by gender, 2005-2010, n=527, 040 from 366 MSAs.

	<b>Males</b>	<b>Females</b>
<b>Cardiovascular disease</b>	-2.24 (-3.23, -1.25)	-2.57 (-3.73, -1.41)
<b>Malignant neoplasms</b>	-0.06 (-0.90, 0.78)	-0.06 (-0.55, 0.42)
<b>Pneumonia or influenza</b>	-0.25 (-0.61, 0.10)	-0.07 (-0.36, 0.22)
<b>Other accidents &amp; adverse events</b>	-0.26 (-0.67, 0.16)	0.03 (-0.29, 0.34)
<b>Motor vehicle accident</b>	-0.68 (-0.88, -0.47)	-0.22 (-0.36, -0.08)
<b>Suicide</b>	0.06 (-0.04, 0.17)	0.02 (-0.03, 0.07)
<b>Chronic liver disease</b>	-0.05 (-0.16, 0.06)	0.03 (-0.03, 0.09)
<b>Drug poisoning, accidental</b>	0.13 (-0.03, 0.29)	0.06 (-0.02, 0.14)
<b>Legal intervention &amp; homicide</b>	-0.35 (-0.64, -0.07)	-0.04 (-0.11, 0.04)
<b>Other-cause mortality</b>	-0.57 (-2.12, 0.99)	-0.21 (-1.67, 1.24)
<b>All-cause mortality</b>	-4.83 (-7.92, -1.73)	-3.24 (-6.06, -0.41)

Sample size 263,520 by gender

Results indicate the absolute change in the mortality rate per 100,000 person years from a one percentage point increase in the MSA-level unemployment rate with 95% confidence interval. Estimates from Poisson regression models offset by log-transformed MSA-demographic specific population estimates.

Regression models include covariates for age, race, and indicator variables (fixed effects) for each MSA and quarter.

**Table 4.** Effect of one percentage point increase in the MSA-level quarterly unemployment rate on the annual mortality rate difference per 100,000 person years by age, 2005-2010, n=316,224 from 366 MSAs.

	<b>Ages 0 - 24</b>	<b>Ages 25 - 64</b>	<b>Ages 65 +</b>
<b>Cardiovascular disease</b>	0.02 (-0.04, 0.08)	-0.72 (-1.22, -0.23)	-9.59 (-13.96, -5.22)
<b>Malignant neoplasms</b>	0.01 (-0.03, 0.06)	-0.13 (-0.53, 0.28)	0.24 (-2.20, 2.68)
<b>Pneumonia or influenza</b>	-0.04 (-0.06, -0.01)	-0.03 (-0.10, 0.05)	-0.55 (-1.95, 0.85)
<b>Other accidents &amp; adverse events</b>	-0.11 (-0.22, -0.00)	-0.15 (-0.36, 0.06)	0.30 (-0.94, 1.54)
<b>Motor vehicle accident</b>	-0.57 (-0.75, -0.39)	-0.45 (-0.63, -0.27)	-0.14 (-0.39, 0.12)
<b>Suicide</b>	-0.04 (-0.14, 0.06)	0.08 (-0.01, 0.17)	0.09 (-0.07, 0.26)
<b>Chronic liver disease</b>	0.00 (-0.00, 0.01)	-0.10 (-0.20, 0.01)	0.30 (0.04, 0.56)
<b>Drug poisoning, accidental</b>	0.03 (-0.04, 0.10)	0.20 (-0.03, 0.43)	-0.01 (-0.09, 0.08)
<b>Legal intervention &amp; homicide</b>	-0.20 (-0.44, 0.04)	-0.24 (-0.42, -0.07)	-0.04 (-0.16, 0.08)
<b>Other-cause mortality</b>	-0.09 (-0.32, 0.14)	-0.97 (-1.87, -0.08)	1.56 (-3.79, 6.91)
<b>All-cause mortality</b>	-0.99 (-1.59, -0.39)	-2.22 (-3.94, -0.50)	-10.66 (-20.79, -0.52)

Sample size 210,816 in 0-24 and 25-44 and 105,408 in 65+

Results indicate the absolute change in the mortality rate per 100,000 person years from a one percentage point increase in the MSA-level unemployment rate with 95% confidence interval. Estimates from Poisson regression models offset by log-transformed MSA-demographic specific population estimates.

Regression models include covariates for sex, race, and age, and indicator variables (fixed effects) for each MSA and quarter.

eTable 1: International Classification of Disease 10<sup>th</sup> revision codes for underlying causes of death

ICD-10	
<b>Major cardiovascular disease</b>	I00-I78
<b>Malignant neoplasms</b>	C00-C97
<b>Pneumonia and influenza</b>	J10-J18
<b>Other accidents &amp; adverse events</b>	V01, V05-V06, V09.1, V09.3-V09.9, V10-V11, V15-V18, V19.3, V19.8-V19.9, V80.0-V80.2, V80.6-V80.9, V81.2-V81.9, V82.2-V82.9, V87.9, V88.9, V89.1, V89.3, V89.9, V90-99, W00-W99, X00-X39, X45-X59, Y40-Y84, Y85-Y86, Y88.1-Y88.3
<b>Motor vehicle accident</b>	V02-V04, V09.0, V09.2, V12-V14, V19.0-V19.2, V19.4-V19.6, V20-V79, V80.3-V80.5, V81.0-V81.1, V82.0-V82.1, V83-V86, V87.0-V87.8, V88.0-V88.8, V89.0, V89.2
<b>Suicide</b>	X60-X84, Y87.0
<b>Chronic liver disease</b>	K70, K73-K74
<b>Drug poisoning, accidental</b>	X40-X44
<b>Legal intervention &amp; homicide</b>	X85-X99, Y00-Y09, Y35, Y87.1, Y89.0

**eTable 2.** Effect of one percentage point increase in the MSA-level quarterly unemployment rate on the annual mortality rate difference per 100,000 person years, 2005-2010, from 366 MSAs.

		Total Population		Males		Females		Ages 0 - 24		Ages 25 - 64		Ages 65 +	
	Type	Estimate	Disp	Estimate	Disp	Estimate	Disp	Estimate	Disp	Estimate	Disp	Estimate	Disp
Cardiovascular disease	Poisson	-2.38 (-3.39, -1.38)	1.425	-2.24 (-3.23, -1.25)	1.221	-2.57 (-3.73, -1.41)	1.401	0.02 (-0.04, 0.08)	0.985	-0.72 (-1.22, -0.23)	1.056	-9.59 (-13.96, -5.22)	1.207
	NB-2	-1.63 (-2.62, -0.64)	1.036	-1.72 (-2.78, -0.66)	1.024	-1.82 (-2.99, -0.64)	1.134	0.02 (-0.04, 0.08)	0.983	-0.66 (-1.15, -0.18)	0.989	-7.79 (-12.12, -3.45)	1.009
Malignant neoplasms	Poisson	-0.07 (-0.64, 0.50)	1.022	-0.06 (-0.90, 0.78)	0.973	-0.06 (-0.55, 0.42)	1.008	0.01 (-0.03, 0.06)	0.986	-0.13 (-0.53, 0.28)	0.988	0.24 (-2.20, 2.68)	1.077
	NB-2	-0.15 (-0.77, 0.46)	0.961	-0.19 (-1.06, 0.69)	0.929	-0.09 (-0.62, 0.44)	0.969	0.01 (-0.03, 0.06)	0.982	-0.12 (-0.53, 0.29)	0.960	-0.05 (-2.54, 2.44)	1.010
Pneumonia or influenza	Poisson	-0.14 (-0.45, 0.16)	1.195	-0.25 (-0.61, 0.10)	1.189	-0.07 (-0.36, 0.22)	1.195	-0.04 (-0.06, -0.01)	0.816	-0.03 (-0.10, 0.05)	0.978	-0.55 (-1.95, 0.85)	1.035
	NB-2	-0.11 (-0.39, 0.17)	1.148	-0.19 (-0.52, 0.14)	1.150	-0.07 (-0.34, 0.21)	1.153	-0.04 (-0.06, -0.01)	0.814	-0.02 (-0.10, 0.05)	0.973	-0.48 (-1.80, 0.84)	0.991
Other accidents & adverse events	Poisson	-0.12 (-0.47, 0.24)	1.178	-0.26 (-0.67, 0.16)	1.168	0.03 (-0.29, 0.34)	1.229	-0.11 (-0.22, -0.00)	1.058	-0.15 (-0.36, 0.06)	1.051	0.30 (-0.94, 1.54)	1.156
	NB-2	-0.13 (-0.48, 0.22)	1.091	-0.26 (-0.68, 0.17)	1.109	0.02 (-0.29, 0.33)	1.179	-0.11 (-0.21, 0.00)	1.023	-0.15 (-0.36, 0.06)	1.021	0.38 (-0.91, 1.67)	1.099
Motor vehicle accident	Poisson	-0.45 (-0.61, -0.30)	1.111	-0.68 (-0.88, -0.47)	1.083	-0.22 (-0.36, -0.08)	1.059	-0.57 (-0.75, -0.39)	1.240	-0.45 (-0.63, -0.27)	1.029	-0.14 (-0.39, 0.12)	1.031
	NB-2	-0.43 (-0.59, -0.28)	1.090	-0.65 (-0.86, -0.44)	1.063	-0.22 (-0.35, -0.08)	1.045	-0.55 (-0.73, -0.37)	1.206	-0.44 (-0.62, -0.26)	1.017	-0.13 (-0.39, 0.13)	1.027
Suicide	Poisson	0.04 (-0.01, 0.10)	1.159	0.06 (-0.04, 0.17)	1.076	0.02 (-0.03, 0.07)	1.277	-0.04 (-0.14, 0.06)	1.298	0.08 (-0.01, 0.17)	1.016	0.09 (-0.07, 0.26)	1.132
	NB-2	0.04 (-0.02, 0.09)	1.155	0.06 (-0.05, 0.16)	1.067	0.02 (-0.03, 0.07)	1.275	-0.04 (-0.14, 0.06)	1.295	0.08 (-0.01, 0.16)	1.007	0.09 (-0.07, 0.26)	1.132
Chronic liver disease	Poisson	-0.01 (-0.08, 0.06)	1.225	-0.05 (-0.16, 0.06)	1.131	0.03 (-0.03, 0.09)	1.175	0.00 (-0.00, 0.01)	0.222	-0.10 (-0.20, 0.01)	1.287	0.30 (0.04, 0.56)	1.121
	NB-2	-0.00 (-0.07, 0.07)	1.208	-0.04 (-0.15, 0.07)	1.122	0.03 (-0.03, 0.09)	1.167	0.00 (-0.00, 0.01)	0.222	-0.09 (-0.19, 0.02)	1.271	0.30 (0.04, 0.56)	1.115
Drug poisoning, accidental	Poisson	0.10 (-0.01, 0.21)	1.296	0.13 (-0.03, 0.29)	1.289	0.06 (-0.02, 0.14)	1.243	0.03 (-0.04, 0.10)	3.315	0.20 (-0.03, 0.43)	1.140	-0.01 (-0.09, 0.08)	0.875
	NB-2	0.07 (-0.03, 0.16)	1.270	0.08 (-0.06, 0.22)	1.261	0.05 (-0.02, 0.13)	1.239	0.03 (-0.04, 0.10)	3.299	0.14 (-0.06, 0.34)	1.075	-0.01 (-0.09, 0.08)	0.875
Legal intervention & homicide	Poisson	-0.20 (-0.36, -0.03)	1.483	-0.35 (-0.64, -0.07)	1.297	-0.04 (-0.11, 0.04)	0.993	-0.20 (-0.44, 0.04)	2.205	-0.24 (-0.42, -0.07)	1.193	-0.04 (-0.16, 0.08)	0.937
	NB-2	-0.15 (-0.29, -0.02)	1.333	-0.29 (-0.52, -0.05)	1.216	-0.03 (-0.11, 0.04)	0.986	-0.14 (-0.33, 0.06)	1.851	-0.20 (-0.36, -0.05)	1.110	-0.04 (-0.16, 0.08)	0.933
Other-cause mortality	Poisson	0.37 (-1.79, 1.04)	1.375	-0.57 (-2.12, 0.99)	1.246	-0.21 (-1.67, 1.24)	1.367	-0.09 (-0.32, 0.14)	0.994	-0.97 (-1.87, -0.08)	1.071	1.56 (-3.79, 6.91)	1.228
	NB-2	-0.77 (-2.36, 0.81)	1.038	-0.90 (-2.75, 0.94)	1.024	-0.52 (-2.07, 1.03)	1.089	-0.09 (-0.31, 0.14)	0.976	-0.82 (-1.58, -0.05)	0.980	2.09 (-3.32, 7.51)	1.016

All-cause mortality	Poisson	-3.95 (-6.80, -1.10)	1.741	-4.83 (-7.92, -1.73)	1.493	-3.24 (-6.06, -0.41)	1.502	-0.99 (-1.59, -0.39)	1.127	-2.22 (-3.94, -0.50)	1.182	-10.66 (-20.79, -0.52)	1.461
	NB-2	-4.19 (-7.10, -1.28)	1.055	-5.51 (-8.99, -2.03)	1.057	-2.45 (-4.97, 0.07)	1.083	-0.93 (-1.46, -0.40)	1.002	-1.94 (-3.41, -0.47)	0.994	-7.27 (-16.20, 1.67)	1.037

Note: Disp = Pearson dispersion statistics, indicating the degree of over-dispersion in the model.

Results using Poisson and negative binomial (NB-2) regression models as indicated, offset by log-transformed MSA-demographic specific population estimates.

Results indicate the absolute change in the mortality rate per 100,000 person years from a one percentage point increase in the MSA-level unemployment rate and 95% confidence interval.

All estimates are from Model 3, which includes covariates for sex, age, race, and indicator variables (fixed effects) for each MSA and quarter.

Total population and by gender, n=527,040; by age group n=316,224.